



# Detecting Leaks in Natural Gas & Propane Commercial Vehicles

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**Federal Motor Carrier Safety Administration**

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**Office of Research and Information Technology**

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# Purpose

- To provide an overview of a two-hour training developed for commercial vehicle inspectors to detect leaks in natural gas & propane heavy trucks & buses
  - Fuel system is 1 out of 14 safety-critical parts of commercial vehicle
  - Serious defects in a safety-critical part are defined by the North American Standard (NAS) Out-Of-Service (OOS) criteria
  - NAS OOS criteria for fuel system calls for a commercial vehicle to be placed Out-Of-Service if it is leaking fuel

# Background – FMCSA

- Federal Motor Carrier Safety Administration (FMCSA)
  - Is the US Department of Transportation (USDOT) agency that regulates the safety of operating & maintaining commercial vehicles
  - Published a Final Report in 2013 at [www.fmcsa.dot.gov/facts-research](http://www.fmcsa.dot.gov/facts-research) on updates to address natural gas commercial vehicles needed in:
    - ❑ Federal Motor Carrier Safety Regulations (FMCSRs)
    - ❑ North American Standard (NAS) inspection procedures
    - ❑ NAS Out-Of-Service Criteria
  - Developed a training for inspectors to detect leaks in natural gas & propane commercial vehicles in response to CVSA

# Background – CVSA

- In 06/2013, Commercial Vehicle Safety Alliance (CVSA) expressed a need to train inspectors to detect leaks in natural gas & propane commercial vehicles.
- CVSA
  - Is a non-for-profit organization of Federal state, & provincial commercial vehicle enforcement officers
  - Develops NAS inspection procedures
  - Develops the NAS Out-Of-Service Criteria
- Nationwide commercial vehicle inspector workforce
  - ~ 150 Federal (mostly along border)
  - ~ 11,000 State, provincial, and local

# Objectives of Training - 1

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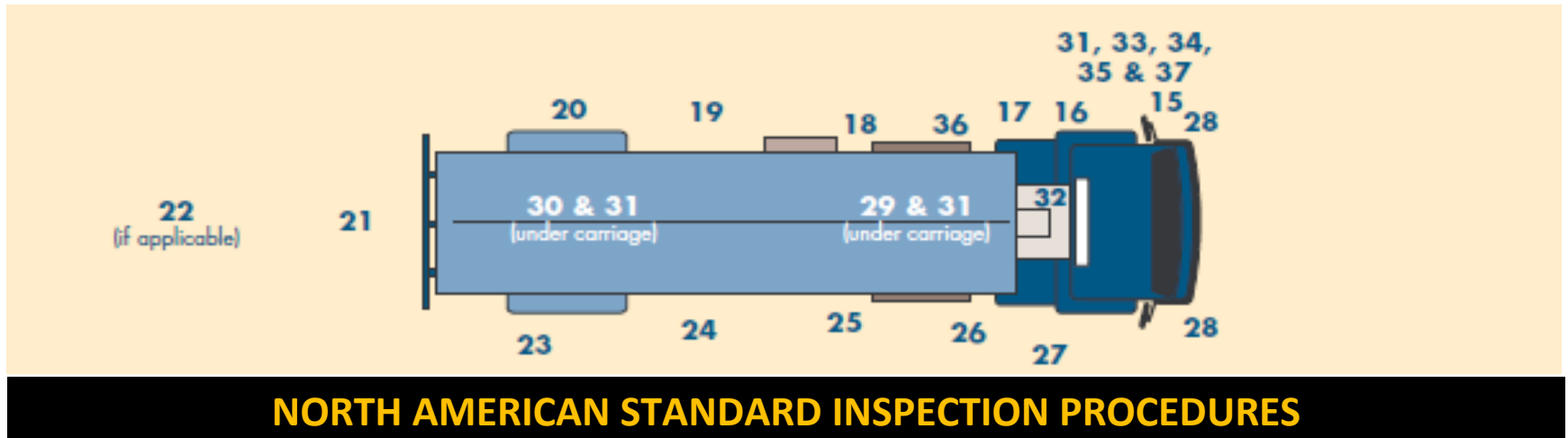
- How inspection of fuel system fits into the NAS commercial motor vehicle inspection procedures
- How to identify a commercial motor vehicle with a fuel system using
  - Compressed Natural Gas (CNG)
  - Liquefied natural Gas (LNG)
  - Liquefied Petroleum Gas (LPG) (aka propane)
- Most important fuel properties for leak detection
- Overview of a typical natural gas or propane fuel system

## Objectives of Training - 2

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- Most likely places in a natural gas or propane fuel system for leak
- Detecting and confirming leaks
  - Human Sensory Clues
  - Soap Bubble Test
  - Combustible Gas Detector
- What to do if a vehicle has a fuel leak

# NAS Inspection Procedures



- STEP 15** Inspect Left Front Side of Tractor

    - Check front wheel, rim, hub, and tire.
  - STEP 16** Inspect Left Saddle Tank Area

    - Check fuel tank area.
    - Check exhaust system.
  - STEP 17** Inspect Tractor Front

    - Check air and electrical lines.
  - STEP 18** Check Left Rear Tractor Area

    - Check wheels, rim, hub, and tire.
    - Check lower fifth wheel.
    - Check upper fifth wheel.
    - Check sliding fifth wheel.
    - Check all required lamps.
  - STEP 19** Inspect Left Side of Trailer

    - Check frame and body.
    - Check condition of beams.
    - Check van and open-top trailer bodies.
    - Check cargo movement.
  - STEP 20** Inspect Left Rear Trailer

    - Check wheels, rim, hub, and tire.
    - Check sliding tractors.
  - STEP 21** Inspect Rear of Trailer

    - Check tail, stop, turn signals, all other required lights and lamp/flaps on projecting loads.
    - Check internal ABS malfunction lamp.
    - Check cargo movement.
  - STEP 22** Inspect Double, Triple and Full Trailers

    - Check safety devices on full trailer/commercial trailers.
    - Check the safety devices (chains/wire rope) for sufficient number, rating, components, inspection, and devices that are incapable of secure attachment. Inspect pinhole leaks, eye and shoulder for cracks, excessive movement, and inspect repairs.
  - STEP 23** Inspect Right Rear Trailer

    - Check as in step 20.
  - STEP 24** Inspect Right Side of Trailer

    - Check as in step 19.
  - STEP 25** Inspect Right Rear Tractor Area

    - Check as in step 18.
  - STEP 26** Inspect Right Saddle Tank Area

    - Check as in step 16.
  - STEP 27** Inspect Right Front Side of Tractor

    - Check as in step 15.
  - STEP 28** Inspect Steering Axle(s)

    - Check steering system (both sides).
    - Check front suspension (both sides).
    - Check frame and frame assembly.
    - Check front brake components (both sides).
    - Mark pushbush (both sides).
  - STEP 29** Inspect Axles 2 and/or 3

    - Check suspension (both sides).
    - Check frame and frame assembly.
    - Check brake components (both sides).
    - Mark pushbush (both sides).
    - Exit under carriage in view of driver.
  - STEP 30** Inspect Axles 4 and/or 5

    - Same as step 29.
  - STEP 31** Check Brake Adjustment

    - Ensure air pressure is 90-100 psi.
    - Have driver fully apply brakes and hold.
    - Measure and record all pushbush noted.
    - Identify size and type of brake chambers.
    - Ensure brakes lining to drum contact.
    - Listen for air leaks.
  - STEP 32** Inspect Tractor Protection System (This procedure tests both the tractor protection system and the emergency brakes.)

    - Have driver release brakes and disconnect both brake lines.
    - Full brake application.
    - Listen for air leaks.
  - STEP 33** Inspect Required Brake Malfunctioning Devices

    - Observe the driver's action when the key is turned "on" for the function test of the malfunction lamp(s) (if applicable).
    - Observe dash gauge while ignition is "on" and the driver is pumping the foot valve to approximately 50 psi for the function test of a low air pressure warning device.
  - STEP 34** Set Air Loss Rate

    - Apply air while the engine is idling, the governor is set to, and pressure is 90-100 psi.
  - STEP 35** Check Steering Wheel Lock

    - Measure steering wheel lock while wheels are straight and the engine is running.
  - STEP 36** Check Fifth Wheel Movement

    - Prepare the driver and vehicle.
    - Check for excessive movement.
  - STEP 37** Complete the Inspection

    - Complete documentation.
    - Conclude with driver.
    - Follow correct and current OOS procedures (if applicable).
    - Issue CVSA (initials) (if applicable).
- Rev June 2010

**Step 16**  
Inspect the left Saddle Tank area

**Step 26**  
Inspect the right Saddle Tank area

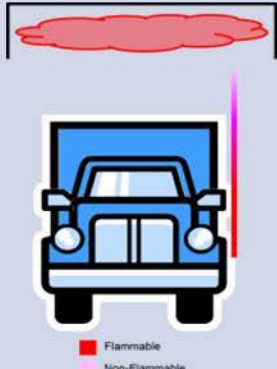
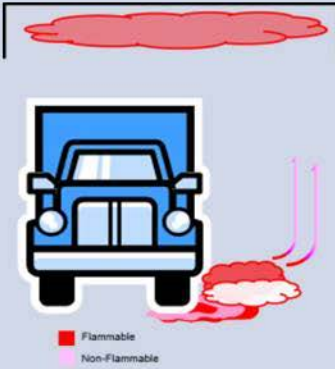
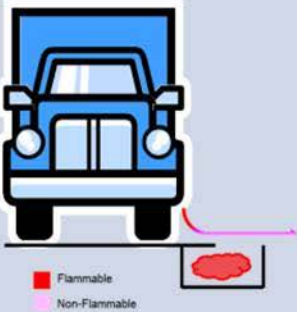
# How to Identify a Vehicle Using CNG, LNG, or LPG

- To identify a natural gas vehicle, look for a **blue** diamond label with the white letters “CNG” or “LNG”
- To identify a LPG vehicle, look for a **black** diamond label with the word “PROPANE” in silver or white
- These labels are NOT required by FMCSA, but by NFPA 52 or NFPA 58, which have been adopted by most states
- Label is on vehicle’s lower rear





# Most Important Fuel Properties for Leak Detection

	CNG	LNG	LPG
<b>State</b>	Compressed Gas (up to 3600 psi)	Cryogenic Liquid <-260 °F	Pressurized Liquid (up to 250 psi)
<b>Color</b>	Colorless	Colorless	Colorless
<b>Odor</b>	Usually, but not always odorized (sulfur smell)	Odorless	Odorized (sulfur smell)
<b>LFL</b>	5% in air	5% in air	2% in air
<b>Leak Profile</b>			

# Odor

- Human senses (eyes) adequate for detecting diesel fuel but not always for natural gas and LPG
- Natural gas and LPG are naturally colorless and odorless
- Odorant (e.g., mercaptan) is added to CNG and LPG but no odorant can be added to LNG to aid in detecting leaks
  - L/CNG can be unodorized
  - LNG is unodorized
- Beware of olfactory fatigue



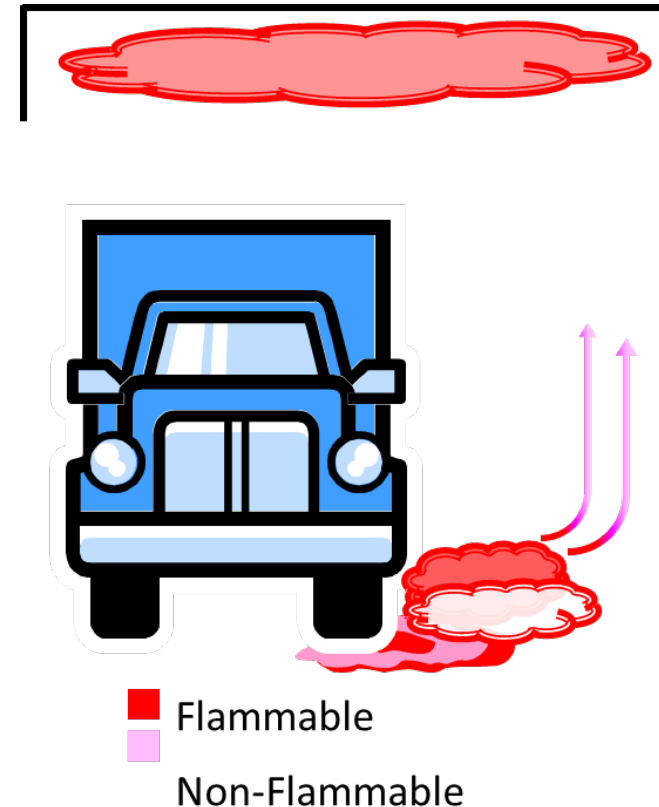
# Lower Flammable Limit (LFL)



- Flammable range is the percent of fuel to air for combustion to occur
  - Flammable range (red area) differs for each fuel
  - Lower flammable limit (LFL) is the lowest percent of fuel to air for combustion (left end of red area in bar)

# Leak Profile

- Natural gas is lighter than air
  - Specific gravity of 0.6 to 0.7
  - Leaks from CNG rise
  - Leaks from LNG may puddle on the ground, but upon warming, they vaporize and
    - Form a cold, dense volume of gas before rising and dissipating
    - Cause water vapor to condense around leaks, producing white vapor clouds of vapor\*
- LPG is heavier than air
  - Specific gravity of 1.5 to 2.0
  - Leaks from LPG fall to the ground



\*(do not use for confirmation)

# Overview of Fuel Systems

- CNG, LNG, and LPG fuel systems have the following in common:
  - Fuel tanks (with pressure relief valve or device)
  - Fuel fill portal
  - Fuel pump
  - Fuel filter
  - Pressure regulator
  - Fuel lines (high and low pressure)
  - Fuel vaporizer (LNG) or evaporator (LPG)



# Most Likely Places in Fuel System for a Leak



Elbows/joints in solid fuel lines



Tank shut-off valve(s)



Connection to engine



Fuel fill



Pressure regulator(s)



Fuel filter

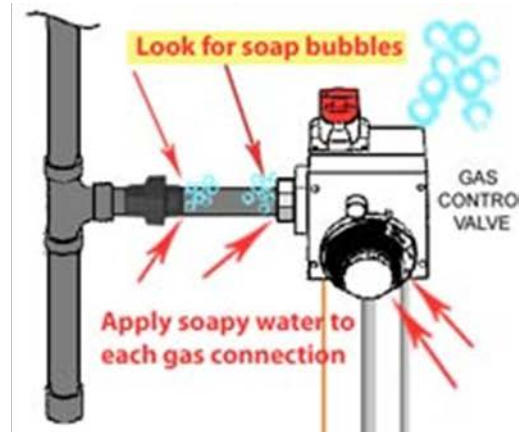
# Detecting and Confirming Leaks

- Human sensory clues
  - Sulfurous smell
  - Hissing sound
  - Puddle on ground and vapor cloud
- Suspected leaks must be confirmed
  - Soap Bubble Test
  - Combustible Gas Indicator
- Vehicles in which suspected leaks cannot be confirmed must be issued a repair order



# Soap Bubble Test

- For a soap bubble test, spray a non-corrosive detergent solution onto suspected leak locations
- Persistent bubbling indicates a leak.
- NEVER check for leaks using a lit match or lighter.





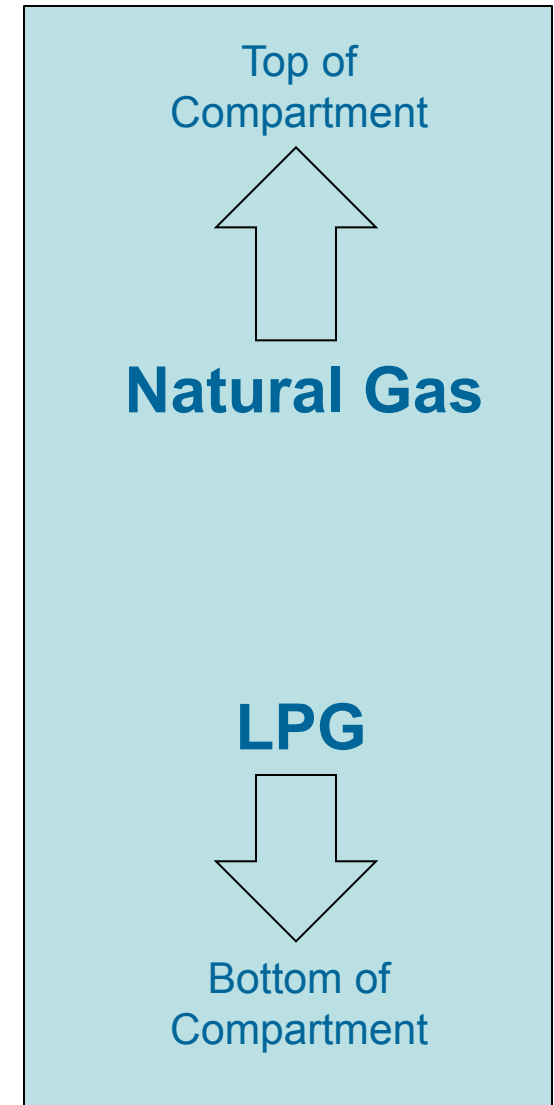
# Combustible Gas Detector

- Detectors cost range: \$50 - \$1000
- Detectors can be used to check for leaks where there are no obvious conventional leak clues
  - Closed compartments
    - ☐ Cab
    - ☐ Engine
    - ☐ Cargo
    - ☐ Fuel storage
- Because detectors are quantitative, they can be used to
  - Pinpoint source of a leak
  - Determine if threshold is exceeded



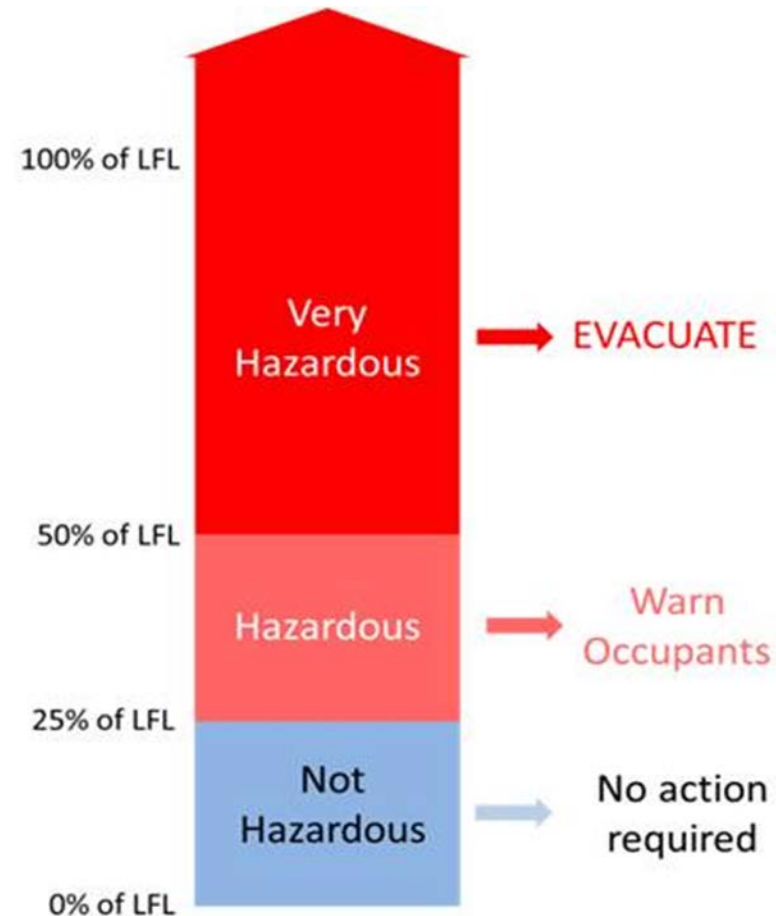
# Apply the Leak Profile When Using a Detector

- When using a detector to check for leaks in closed compartments,
  - Cab
  - Engine
  - Cargo
  - Fuel storage
- Natural gas vapors rise so use the detector to check the top of the compartment
- LPG vapors fall so use the detector to check the bottom of the compartment



# Threshold for Placing a Vehicle Out-Of-Service

- Recommended Out-Of-Service (OOS) threshold is 25% of LFL because of its generally accepted use
  - LPG has LFL of 2%, thus, threshold should be 0.5% or 5,000 ppm
  - Natural gas has LFL of 5%, thus, threshold should be 1.25% or 12,500 ppm



# What to Do If a Vehicle Has a Fuel Leak

- Issue an OOS order for the vehicle
  - For a combination vehicle, only the power unit (tractor) is placed OOS
    - ☐ Not the trailer(s)
    - ☐ Not the driver
- A vehicle placed OOS for a fuel leak must **NOT** be
  - Operated
  - Moved or towed unless
    - ☐ De-fueled or
    - ☐ Necessary to move it a short distance to a safer place
  - Stored indoors unless the facility is approved for storage of natural gas or LPG vehicles

# Summary

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- How inspection of fuel system fits into the NAS inspection procedures
- How to identify a commercial vehicle with a fuel system using natural gas or propane
- Most important fuel properties for detecting leaks of natural gas or propane
- Overview of natural gas and propane fuel systems
- Most likely places for a leak in such fuel systems
- Detecting and confirming leaks
- What to do if a vehicle has a fuel leak

# Link to Web-based Training for Leak Detection

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- For those who have a copy of this presentation

<http://endynafmcsa.articulate-online.com/7987091858>

- For those who want it e-mailed, please see contact information

# Contact Information

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